# Evaluating the Observational Analysis in Regional Water Budgets of Reanalyses

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## 1. Motivation

**Evaluating MERRA and Interim global and regional water cycles, Trenberth et al. (2011) show long term avg moisture divergence over the central United States. What part of the observing system and analysis influence this?**

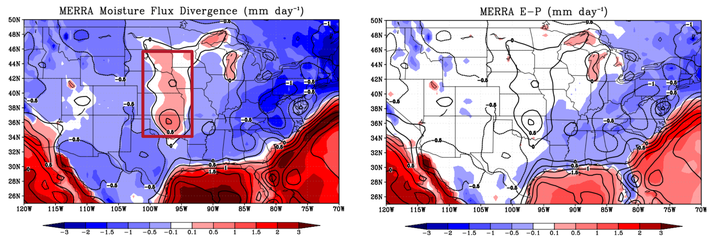


Figure 1 MERRA moisture flux divergence (left) and E-P (right) compared to the analysis increment of water vapor (contour) for the period 2002-2008 following Trenberth et al. (2011). Units mm day$^{-1}$

## 2. Temporal variations of budget terms

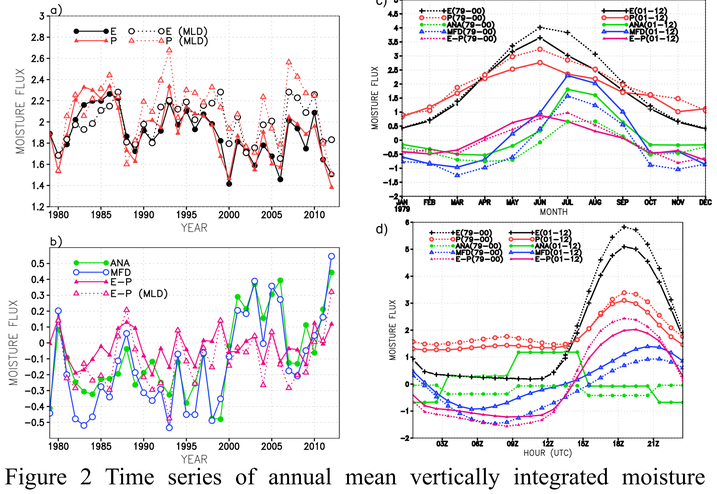


Figure 2 Time series of annual mean vertically integrated moisture budget (mm/day) over the central United States (red box in Fig 1) from MERRA and MERRA-LAND (MLD) (a-b). Mean annual cycles (c) and diurnal cycle (d) for the periods listed in the legend.

**The water vapor increment interannual variations are tightly coupled with MFD. While this follows to the annual cycle, it does not follow in the diurnal cycle. Any direct influence of the increments on precipitation or evaporation, or vice versa.**

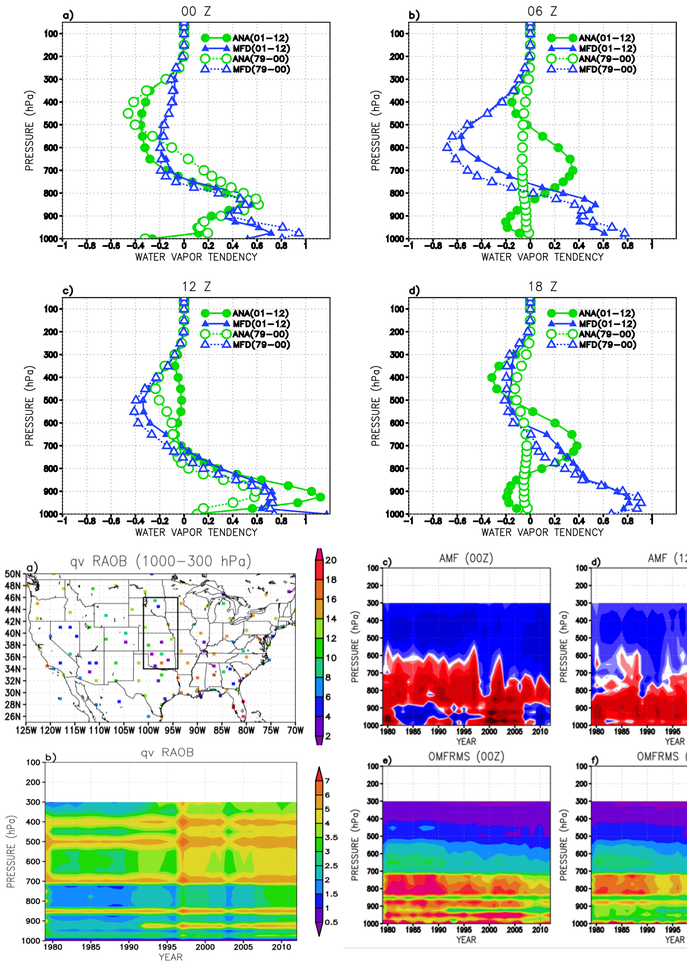





Figure 4 Left – Data counts (x1000) for RAOB water vapor measurements in space and in the vertical over time. Analysis departure (AmF, top right), and root mean square error of forecast departure (lower right) from RAOB over the central United States at 00Z (left) and 12Z (right). Units are g/kg.

## 3. Water vapor analysis increment and forecast departure

**The water vapor analysis increments show a distinct shift, but more noticeable at 06Z and 18Z. A change point detection routine identifies spring 2001 when the shift occurs. This is the first warm season, after the start of NOAA16 ATOVS. In 06Z and 18Z, analysis increments change from nearly zero to significant tendencies (Figure 3).**

**The MERRA GIO data provide innovation statistics from the analysis (e.g. O-F, O-A, A-F) as well as the observations. Figure 4 shows that the analysis of RAOB Qv shows consistent increments at 12Z, and several variations in the 00Z analysis. The RAOB increments are quite different than those at 06Z and 18Z.**

### Gridded Innovations and Observations (GIO)

The MERRA GIO collection of data includes the conventional and radiance observations that have been assimilated, and the forecast error (O-F) and analysis error (O-A). These provide useful statistics to evaluate the model and analysis (Rienecker et al. 2011).

Figure 3 Figure 10 Vertical profiles of water vapor tendency ANA and MFD terms at a) 00Z, b) 06Z, c) 12Z, and d) 18Z over the central United States for period 1979-2000 (dot lines) and 2001-2012 (solid lines).

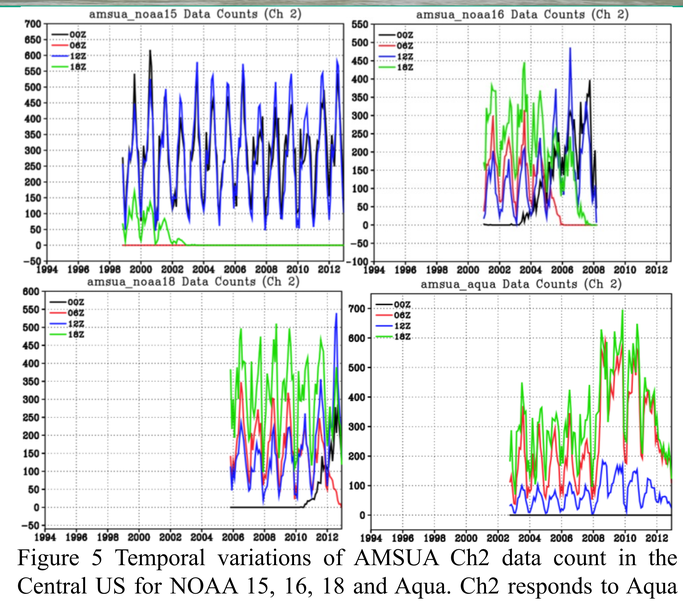


Figure 5 Temporal variations of AMSUA Ch2 data count in the Central US for NOAA 15, 16, 18 and Aqua. Ch2 responds to Aqua Ch 4 is turned off for a problem at the end of 2007.

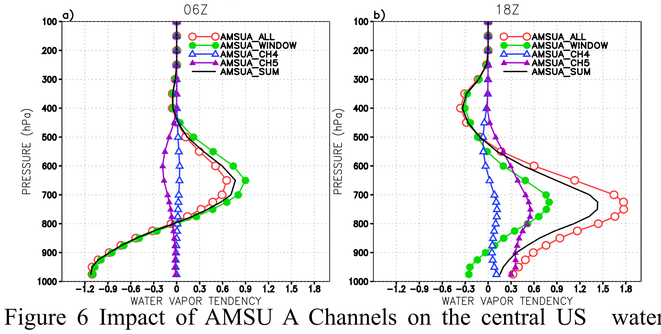


Figure 6 Impact of AMSU A Channels on the central US water vapor analysis increments

## 4. Summary

**The long term central US moisture divergence is generally responding to JJA water increments. Data withholding experiments identify AMSU A Window channels and channel 5 as most influential on the water vapor increments (Figure 5). Data denial experiments showed little impact from HIRS3, AMSUB, and AIRS, while AMSUA window channels and ch5 (at 18Z) had most impact on central US increments (Fig 6).**

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